Climate Change Effects on Waves, Typhoons and Storm Surges

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Abstract. This study shows projections of present and future wave climate, typhoon and storm surge using the data of high-resolution atmospheric General Circulation Model and with numerical models of global wave simulation, stochastic typhoon simulation and storm surge simulation.

Keywords: Global Warming, Waves, Typhoons, Storm Surges

1. INTRODUCTION

This abstract summarizes resent studies of The Maritime Disasters Section, Disaster Prevention Research Institute, Kyoto University.

Firstly, this paper introduces projection of future wave climate and analysis of differences between present and future ocean wave climate using the data of high-resolution atmospheric General Circulation Model (GCM) developed by Japanese Meteorological Research Institute and Japan Meteorological Agency (MRI-JMA) and a global wave model. Secondly, a stochastic typhoon model for estimating characteristics of typhoons from cyclogenesis to cyclolysis in both present and future climate conditions is described. Differences of statistical characteristics between present and future typhoons are estimated from the projections by the GCM, and these differences are taken into account in the stochastic model of future typhoons. Finally, storm surges in future climate are projected and analyzed.

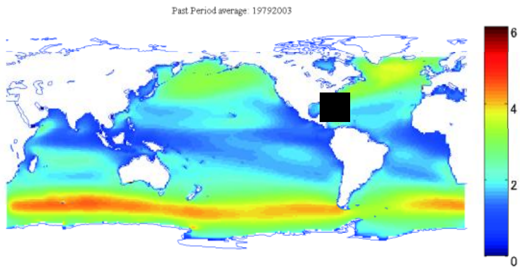
2. RESULTS

2.1. Wave Climate

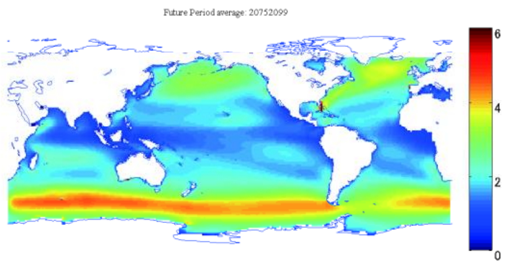
The important characteristics of future projection are not only extreme wave climate but also daily wave climate.

Figure 1 shows the mean (a period-averaged) significant wave height (denotes *Hs* hereafter) in the present and future climate (Florida area is excluded for the analysis following validation results). Regarding the differences of *Hs* between the present and future climates, there is regional dependence for *Hs* similar to wind speed at 10 m height. There are remarkable characteristics of large scale pattern change of averaged *Hs* from the present to future climate.

The small wave height region on the equator is expanded to both north and south directions. On the other hand, large wave height region in the Antarctic Ocean is expanded from the present to future climate.



(a) present climate



(b) future climate

Fig. 1. Averaged significant wave height.

2.2. Future Typhoon Projection by Stochastic Typhoon Model (STM)

To utilize the analyzed changes of typhoon characteristics by GCM, existing Best Track (BT) data was modified so as to have the characteristics of changes between present and future typhoons.

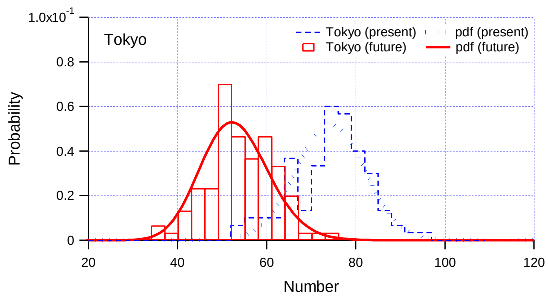
The locations of cyclogenesis and cyclolysis of BT data are changed proportionally according to the lognormal pdf's change. The stochastic procedure in the future experiment follows that for BT. Since the number of typhoons in the future climate is estimated to decrease from 20 to 16 by AGCM, the average number of typhoon genesis in the log-normal pdf will decrease from the observed average of 24.7 to 19.5

and the standard deviation will also decrease from the current 5.6 to 4.3. These averaged statistical characteristics are taken into account to the STM.

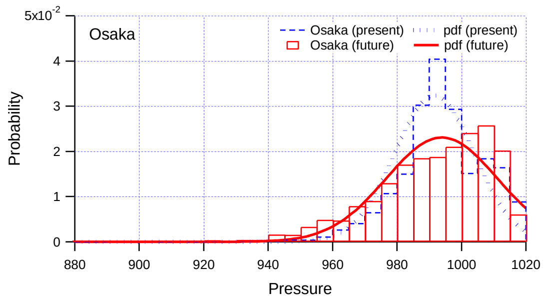
As shown in Fig. 2(a), the number of possible typhoon events will decrease in Osaka Bay area. This is expected because the number of future cyclogenesis is given smaller than present climate. However, the number of future cyc-logenesis is decreased about 21% in the whole do-main but number of future typhoon approaching to Osaka bay is decreased 30%. This is the influence of shift of typhoon tracks and cyclolysis.

The both typhoon number and track information are important to discuss projections of future typhoon characteristics. The lowest central atmospheric pressures of the typhoons passing over major bays will stay approximately the same in the future as shown in Fig. 2(b).

One of the most significant results is the suggestion that for three major bays (Osaka, Ise, Tokyo) the possibility of intense typhoons with central atmospheric pressure lower than 960 hPa will increase in the future. Although the average typhoon intensity will not change, extreme conditions will become more severe.



(a) Number of attacking typhoons

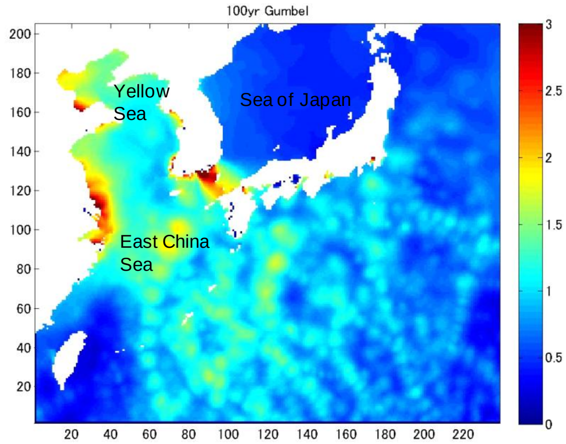


(b) Lowest central atmospheric pressure

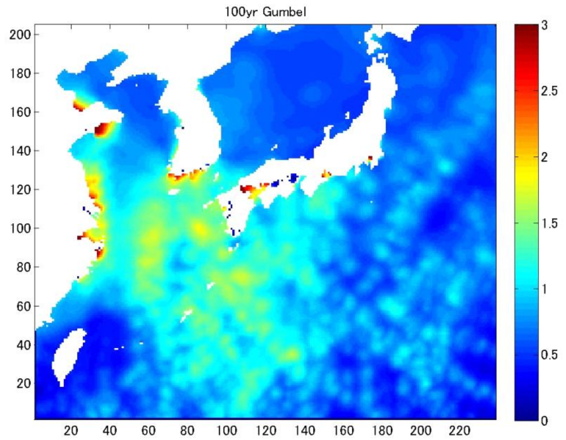
Fig. 2. Statistical properties of typhoons

2.3. Storm Surges

Figure 3 displays the 100 years return period values of storm surges in East Asia, obtained from simulations, for the present and future climates. In the present climate, high storm surge areas are recognized along the east coast of China, in the Tsushima Straight between Korea and Japan, and in the innermost bay of the Yellow Sea (the Bohai Sea). The predicted maximum storm surge height decreases significantly along the Chinese east coast and in the Tsushima Straight in the future climate. The location of severe storm surges in the Yellow sea are also slightly changed, moving from Bohai Bay to the Shandong Peninsula. The East China Sea remains as a vulnerable area because quite a number of intense tropical cyclones pass through it in the future climate, as at present.



(a) Present



(b) Future

Fig. 3. Estimated maximum storm surges in East Asia with a return period of 100 years.